

and are made using a number of commercially available components, making them extremely inexpensive.

In the latest MXS design, UV efficiency is addressed by using a high-gain electron multiplier. The photocathode is vapor-deposited onto the input cone of a Burle Magnum™ multiplier. This system

yields an extremely robust photon-driven electron source that can tolerate long — weeks or more — exposure to air with negligible degradation. The package is also small. When combined with the electron target, necessary vacuum fittings, and supporting components (but not including LED electron-

ics or high-voltage sources), the entire modulated x-ray source weighs as little as 158 grams.

This work was done by Keith Gendreau, Zaven Arzoumanian, Steve Kenyon, and Nick Spartana of Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-16287-1

Hollow-Fiber Spacesuit Water Membrane Evaporator

Commercial applications include personal coolers for infantry, humidifiers for pilots, and personal coolers for hazmat suits.

Lyndon B. Johnson Space Center, Houston, Texas

The hollow-fiber spacesuit water membrane evaporator (HoFi SWME) is being developed to perform the thermal control function for advanced spacesuits and spacecraft to take advantage of recent advances in micropore membrane technology in providing a robust, heat-rejection device that is less sensitive to contamination than is the sublimator. After recent contamination tests, a commercial-off-the-shelf (COTS) microporous hollow-fiber membrane was selected for prototype development as the most suitable candidate among commercial hollow-fiber evaporator alternatives. An innovative design that grouped the fiber layers into stacks,

which were separated by small spaces and packaged into a cylindrical shape, was developed into a full-scale prototype for the spacesuit application.

Vacuum chamber testing has been performed to characterize heat rejection as a function of inlet water temperature and water vapor backpressure, and to show contamination resistance to the constituents expected to be found in potable water produced by the wastewater reclamation distillation processes. Other tests showed tolerance to freezing and suitability to reject heat in a Mars pressure environment. In summary, HoFi SWME is a lightweight, compact evaporator for heat rejection

in the spacesuit that is robust, contamination-insensitive, freeze-tolerant, and able to reject the required heat of spacewalks in microgravity, lunar, and Martian environments.

The HoFi is packaged to reject 810 W of heat through 800 hours of use in a vacuum environment, and 370 W in a Mars environment. The device also eliminates free gas and dissolved gas from the coolant loop.

This work was done by Grant Bue and Luis Trevino of Johnson Space Center; Gus Tsioulos of Wyle; Keith Mitchell of Jacobs Technology, Inc.; and Joseph Settles of Barrios. Further information is contained in a TSP (see page 1). MSC-24849-1

High-Power Single-Mode 2.65-μm InGaAsSb/AlInGaAsSb Diode Lasers

This innovation is useful for targeted gas detection instruments in environmental monitoring, safety, quality control, and fundamental science applications.

NASA's Jet Propulsion Laboratory, Pasadena, California

Central to the advancement of both satellite and in-situ science are improvements in continuous-wave and pulsed infrared laser systems coupled with integrated miniaturized optics and electronics, allowing for the use of powerful, single-mode light sources aboard both satellite and unmanned aerial vehicle platforms.

There is a technological gap in supplying adequate laser sources to address the mid-infrared spectral window for spectroscopic characterization of important atmospheric gases. For high-power applications between 2 to 3 μm, commercial laser technologies are unsuitable because of limitations in output power. For

instance, existing InP-based laser systems developed for fiber-based telecommunications cannot be extended to wavelengths longer than 2 μm. For emission wavelengths shorter than 3 μm, intersubband devices, such as infrared quantum cascade lasers, become inefficient due to band-offset limitations. To date, successfully demonstrated single-mode GaSb-based laser diodes emitting between 2 and 3 μm have employed lossy metal Bragg gratings for distributed-feedback coupling, which limits output power due to optical absorption.

By optimizing both the quantum well design and the grating fabrication process, index-coupled distributed-feed-

back 2.65-μm lasers capable of emitting in excess of 25 mW at room temperature have been demonstrated. Specifically, lasers at 3,777 cm⁻¹ (2.65 μm) have been realized to interact with strong absorption lines of HDO and other isotopologues of H₂O. With minor modifications of the optical cavity and quantum well designs, lasers can be fabricated at any wavelength within the 2-to-3-μm spectral window with similar performance. At the time of this reporting, lasers with this output power and wavelength accuracy are not commercially available.

Monolithic ridge-waveguide GaSb lasers were fabricated that utilize second-order lateral Bragg gratings to generate

single-mode emission from InGaAsSb/AlInGaAsSb multi-quantum well structures. The device fabrication utilizes etched index-coupled gratings in the top AlGaAsSb cladding of the laser chip along the ridge waveguide, whereas commercial lasers that emit close to this wavelength include loss-coupled metal gratings that limit the output power of the laser.

Semiconductor-laser-based spectrometers can be used to replace gas sensors currently used in industry and govern-

ment. With the availability of high-power laser sources at mid-infrared wavelengths, sensors can target strong fundamental gas absorption lines to maximize instrument sensitivity.

This work was done by Clifford F. Frez, Ryan M. Briggs, Siamak Forouhar, and Carl E. Borgentun of Caltech; and James Gupta of the National Research Council, Canada for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov.

In accordance with Public Law 96-517,

the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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Refer to NPO-48926, volume and number of this NASA Tech Briefs issue, and the page number.

Optical Device for Converting a Laser Beam Into Two Co-aligned but Oppositely Directed Beams

Goddard Space Flight Center, Greenbelt, Maryland

Optical systems consisting of a series of optical elements require alignment from the input end to the output end. The optical elements can be mirrors, lenses, sources, detectors, or other devices. Complex optical systems are often difficult to align from end-to-end because the alignment beam must be inserted at one end in order for the beam to traverse the entire optical path to the other end. The ends of the optical train may not be easily accessible to the alignment beam.

Typically, when a series of optical elements is to be aligned, an alignment laser beam is inserted into the optical path with a pick-off mirror at one end of the series of elements. But it may be impossible to insert the beam at an end-

point. It can be difficult to locate the pick-off mirror at the desired position because there is not enough space, there is no mounting surface, or the location is occupied by a source, detector, or other component. Alternatively, the laser beam might be inserted at an intermediate location (not at an end-point) and sent, first in one direction and then the other, to the opposite ends of the optical system for alignment. However, in this case, alignment must be performed in two directions and extra effort is required to co-align the two beams to make them parallel and coincident, i.e., to follow the same path as an end-to-end beam.

An optical device has been developed that accepts a laser beam as input and produces two co-aligned, but counter-

propagating beams. In contrast to a conventional alignment laser placed at one end of the optical path, this invention can be placed at a convenient position within the optical train and aligned to send its two beams simultaneously along precisely opposite paths that, taken together, trace out exactly the same path as the conventional alignment laser. This invention allows the user the freedom to choose locations within the optical train for placement of the alignment beam. It is also self-aligned by design and requires almost no adjustment.

This work was done by Donald Jennings of Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-16610-1

A Hybrid Fiber/Solid-State Regenerative Amplifier with Tunable Pulse Widths for Satellite Laser Ranging

Applications include materials processing, remote detection, and high-resolution 3D image mapping.

Goddard Space Flight Center, Greenbelt, Maryland

A fiber/solid-state hybrid seeded regenerative amplifier, capable of achieving high output energy with tunable pulse widths, has been developed for satellite laser ranging applications. The regenerative amplifier cavity uses a pair of Nd:YAG zigzag slabs oriented orthogonally to one another in order to make thermal lensing effects symmetrical and simplify optical correction schemes. The seed laser used is a fiber-coupled 1,064-nm narrowband

(<0.02 nm) diode laser that is discretely driven in a new short-pulsed mode, enabling continuously tunable seed pulse widths in the 0.2-to-0.4-ns range.

The amplifier gain unit consists of a pair of Brewster-cut 6-bounce zigzag Nd:YAG laser slabs, oriented 90° relative to each other in the amplifier head. This arrangement creates a net-symmetrical thermal lens effect (an opposing single-axis effect in each slab), and makes

thermo-optical corrections simple by optimizing the curvature of the nearest cavity mirror. Each slab is pumped by a single 120-W, pulsed 808-nm laser diode array. In this configuration, the average pump beam distribution in the slabs had a 1-D Gaussian shape, which matches the estimated cavity mode size. A half-wave plate between the slabs reduces losses from Fresnel reflections due to the orthogonal slabs' Brewster-cut end faces.